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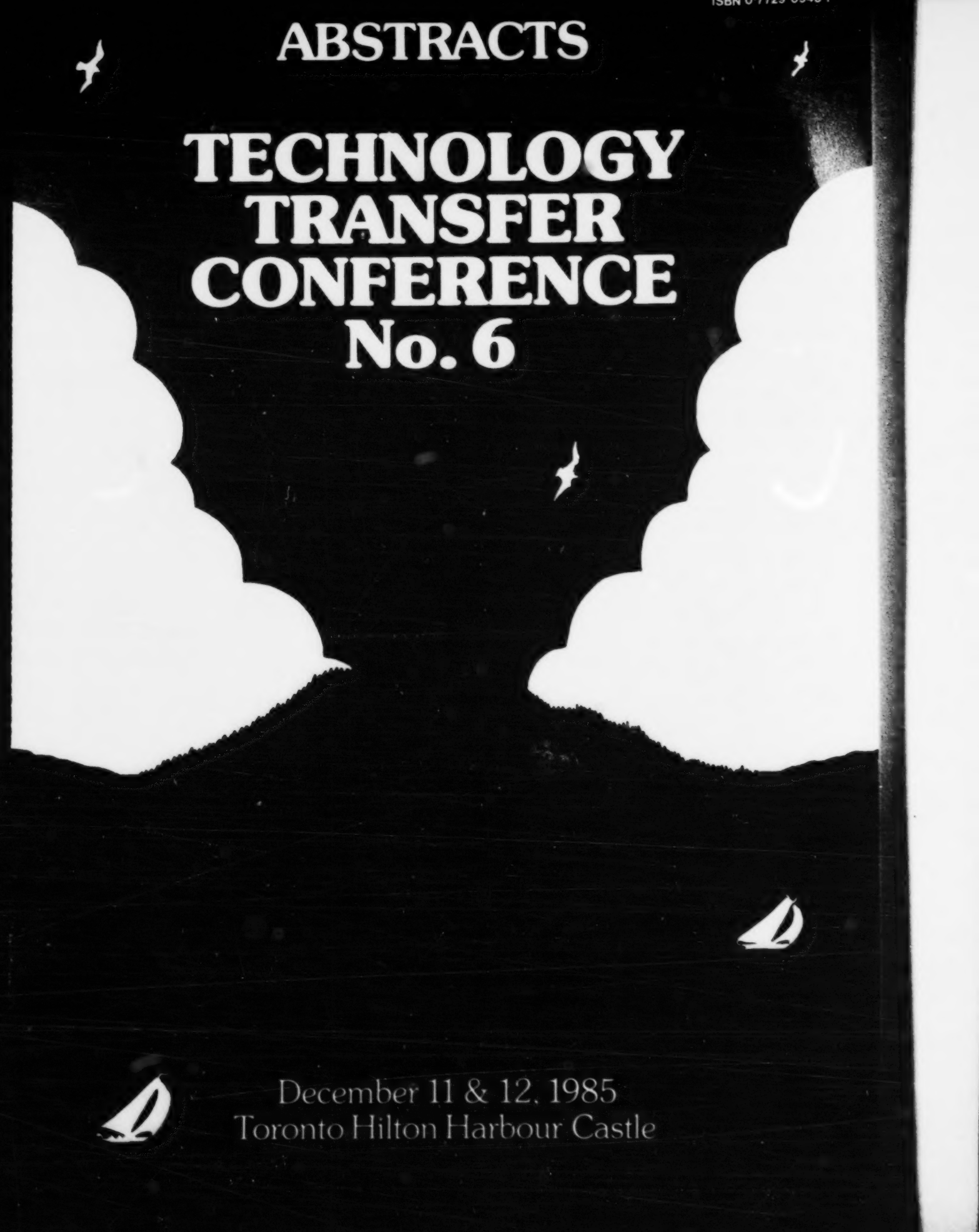
ABSTRACTS

TECHNOLOGY TRANSFER CONFERENCE No. 6



December 11 & 12, 1985
Toronto Hilton Harbour Castle

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ABSTRACTS

TECHNOLOGY TRANSFER CONFERENCE NO. 6

December 11 & 12, 1985

Toronto Hilton-Harbour Castle

External Research Projects

Organized by
Research Advisory Committee

Sponsored by

Policy & Planning Branch
Ministry of the Environment
Ontario

Goal Statement

"To achieve and maintain a quality of the environment - including air, water and land - that will protect human health and the ecosystem and will contribute to the well- being of the people of Ontario."

ACKNOWLEDGEMENTS

The Conference Organization Committee would like to thank the invited speakers, investigators and the National Research Council of Canada for their valuable contributions.

DISCLAIMER

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INTRODUCTION

The Ontario Ministry of the Environment holds its annual Technology Transfer Conference to report and publicize the progress made on Ministry-funded projects. These studies are carried out in Ontario universities and by private research organizations.

This booklet presents abstracts of the papers presented at Technology Transfer Conference No. 6, held in December 1985. The abstracts are divided into three sections, corresponding to the conference sessions, dealing with air quality research, water quality research, and liquid and solid waste research. Papers dealing with analytical methods and instrument development are assigned to each of the three sections.

For further information on any of the projects, the reader is kindly referred to the Conference Proceedings (ISSN 0-825-491), or to the principal investigators.

FEATURE PAPERS

IDENTIFICATION AND COMPARATIVE RISK ASSESSMENT OF AIRBORNE CARCINOGENS FROM COMBUSTION SOURCES

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ABSTRACT

The identification and assessment of airborne carcinogens have been significantly advanced by the use of short-term genetic bioassays. Bioassay-directed fractionation, coupled with new organic characterization methods, has provided the tools needed for more efficient identification of potential carcinogens in complex combustion emissions and urban air samples. These studies have shown that a significant portion of the mutagenicity is found in fractions more polar than polynuclear aromatic hydrocarbons (PAHs). New mass spectrometry techniques have been developed to identify and quantify the more polar mutagens in these samples.

The comparative mutagenicity and carcinogenicity of a series of combustion emissions have been assessed using dose-response studies in bacteria, mammalian cells and rodents. This data base has been used to develop a comparative potency risk assessment methodology for a series of combustion emissions.

CHLORINATED DIOXINS AND DIBENZOFURANS IN ONTARIO - CRITERIA FOR DEVELOPING ENVIRONMENTAL STANDARDS

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Ontario Ministry of the Environment, Intergovernmental Relations & Hazardous Contaminants Co-ordination Branch

ABSTRACT

In Ontario, dioxins and furans occur as complex mixtures (not as pure 2,3,7,8-T_4CDD), especially in incineration sources. These were determined to be a major source of exposure in Ontario. Since 2,3,7,8-T_4CDD is not prevalent in Ontario, concern was principally for isomers other than 2,3,7,8-T_4CDD.

Since the time required to accumulate toxicological data on other isomers may run into decades, the decision was made to use the apparent toxic potency relationships of other PCDDs and PCDFs to 2,3,7,8-T_4CDD in order to proceed with a control strategy for PCDDs and PCDFs at this time.

A risk analysis approach was taken with the toxicological assessment being conducted in parallel with the environmental/sources/fate/exposure assessment.

The conclusion of the environmental sources/fate assessment was that the major sources of PCDDs and PCDFs in the Ontario environment were:

(1) combustion sources including municipal refuse and sewage sludge incineration, and

(2) the use of chlorinated phenols.

Based on the exposure assessment, the major routes of exposure are in order of decreasing contribution:

(i) ambient air in the vicinity of incineration sources;
(ii) diet, especially some sport fish from Lake Ontario;
(iii) atmospheric PCDDs/PCDFs deposited on soil, mainly to children.

VOLATILE ORGANIC CARBON FROM LAND DISPOSAL OF WASTE - MECHANISMS OF EMISSIONS AND CONTROL STRATEGIES

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ABSTRACT

Organic wastes in solid and liquid form have been and will likely continue to be disposed of on or near the land surface. Disposal can take the form of treatment or storage. In mixture form, the individual chemical species exert some finite vapor pressure which ultimately can result in transport to the air. A review of vaporization mechanisms for waste in surface improvements, land farms and landfills will be presented. Models and experimental tests of control strategies will also be presented.

TOXICOLOGICAL EVALUATION OF GREAT LAKES DRINKING WATER

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ABSTRACT

A scientifically sound and defensible basis for the evaluation of human health effects requires a thorough knowledge of two elements: the toxicity of the chemical or process in question, particularly as it applies to humans, and the exposure to the chemical or process in question to which the average person or a specific group of persons is subject.

Many chemicals are found in the Great Lakes and many of these are not removed by filtration or other methods of purification. In addition, several chemicals are added to water or formed during the purification process and the potential hazard of these needs to be assessed.

This paper will address the significance of chemicals found in drinking water from the Great Lakes in several ways which will include the following:

- Estimation of exposure for water and other sources;
- The toxicological database available for the chemicals found in the Great Lakes;
- The assessment of the significance of the toxicology database in regard to human health;
- The significance of epidemiological evidence of health effects.

The presentation will stress methodology and will be illustrated through the use of case histories.

SESSION A

AIR QUALITY RESEARCH

BIOLOGICAL AND CHEMICAL TESTING OF COKE OVEN EMISSIONS

G. Thomas, J. Craigmile, B. Das and A. Horton
Ontario Research Foundation

Key words: PAH, Coke Oven Emissions, Air Pollution, Mutagenicity, Organic Analysis.

ABSTRACT

Ambient air studies in Ontario and elsewhere have shown that polycyclic aromatic hyrdocarbons (PAH) are present in urban and rural air. In some areas coke ovens are a significant contributor to the ambient PAH concentrations, but it is difficult to assess the degree of hazard this poses to the populations in surrounding areas.

This study relates to coke oven emissions, especially with respect to the mutagenicity and chemical nature of solvent extractable fractions of collected particulate material.

Representative HiVol and LoVol samples of coke oven emissions have been collected. Samples were taken directly from the coke oven through a hole drilled in a lid, every hour throughout a complete coking cycle. Simultaneously, samples were collected from on top of the coke oven. The HiVol sample filters were backed up by polyurethane (PUF) foam plugs.

LoVol filters were extracted with benzene. These data provided the benzene soluble fraction of total particulate matter (BSFTPM) to be used as markers to compare with existing occupational data. HiVol filters and PUF plugs were extracted with dichloromethane (DCM). The decision to use DCM was made after suitable experimentation (bioassay and chemical) with separate benzene and DCM extracts.

Organic soluble fractions from selected Lid and Top Side HiVol samples were used in two-tiered short-term mutagenicity assays, namely, a bacterial test (Ames) and a tissue culture test (SCE-CHO). Concurrent chemical analysis was performed on portions of the samples used for the biological assays. In some instances, limited fractionation of the samples prior to chemical analysis was performed.

The sampling and testing protocols were performed at three coke oven locations in Ontario. The results of the biological assays and the concurrent chemical analyses for the selected soluble organic fractions of the HiVol samples will be discussed.

EXPERIMENTALLY DETERMINED MUTATION RATES IN LUNG AND BRONCHIAL EPITHELIA AS A PRIMARY AIR POLLUTION STANDARD

J.A. Heddle, K. Jain, H. Kaul, and D.B. Couch
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Key words: Mutagenicity Assays, Air Pollution, Mutation Rates, Health Effects, Inhalable Particulates, Exposure.

ABSTRACT

One of the health hazards arising from the inhalation of polluted air is cancer of the lung and trachea. Since epidemiological studies of exposed populations and animal cancer bioassays are too cumbersome to be used as primary standards for air pollution, a more practical standard must be used. This project is dedicated to developing a more relevant biological standard than raw particle counts or benzpyrene determinations. The central role played by mutation in the carcinogenic process suggests that measurement of mutation rates in the lung and tracheal cells could provide such a standard.

Normally, mutation rates are measured by determining the proportion of cells that can form colonies under conditions that permit mutant cells to grow but not unmutated cells. This restricts the cells in which measurements of mutation frequency can be made to those for which there are excellent culture conditions available. Recently, however, we have developed a technique designed to bypass these difficulties and to permit measurement of mutation rates in a variety of primary cell types that can be maintained in culture but not cloned efficiently, such as those of lung and trachea. The concept has been shown to work successfully in the CHO cell line where a wide variety of mutagens were detected and the assay validated. The assay detects mutation to diphtheria-toxin-resistance, one of the standard loci used in the traditional colony-formation assays. The resistance to the toxin, which acts by inhibiting protein synthesis, is detected not by colony formation but rather autoradiographically after exposure of the intoxicated cell population to tritiated leucine. Mutants resistant to the toxin will continue to synthesize protein and thus will be labelled, whereas cells that have been killed by the toxin will not. The conditions for a successful assay were indicated by the work in CHO cells, which has been published [Ronen et al, PNAS 81 (1984)].

Since then, work has proceeded on the mammary, colonic, and lung epithelia which are at various stages of development. In the mammary and colonic epithelia, the conditions for the assay have been worked out and the assay applied to model carcinogens active in these tissues. In the lung and trachea, which work was begun much more recently, we have succeeded in developing and standardizing the isolation and culture techniques sufficiently well so as to permit commencement of the experiments that will determine the appropriate selection conditions.

FACTORS THAT INFLUENCE ASSESSMENTS OF HEALTH EFFECTS OF AIR POLLUTION

P. Corey, F. Silverman, A. Ayiomamitis, S. Mintz, and H.R. Hosein
The Gage Research Institute, Departments of Medicine and Preventive Medicine and Biostatistics, University of Toronto

Key words: Health Effects, Air Monitoring, Air Pollution, Exposure, Air Particulates.

ABSTRACT

Health effects of air pollution were examined in 30 asthmatics and 14 healthy non-asthmatics. The objectives were: (1) to assess exposure in 4 ways - personal (P), inside (I) and outside (O) the home, and at a fixed air pollution monitoring site (GMOE) in downtown Toronto; (2) to examine the relationship among the estimates of exposure; and (3) to assess the relative strength of the four estimates of exposure as demonstrated by its association with measures of health effects. Small portable multipollutant samplers for nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter were carried by the subjects, placed inside and outside the home and at a downtown Toronto air pollution monitoring station. Subjects were each visited on approximately 20 days; pulmonary function (spirometry) was assessed in the morning at the beginning of sampling, and again at the end of the day when sampling was terminated; a questionnaire was completed (symptoms, medications, daily activities and exposure to other potential irritants).

Analyses have been performed to measure the relationship between estimates of pollution exposure, home and lifestyle characteristics, and season of the year on symptoms and pulmonary function. The effect of season is very strong both for pulmonary function and symptom frequency. Furthermore, the relationship between pollutant exposure and pulmonary function is strongly dependent on season.

Regression analyses have been performed to determine whether the estimate of exposure using the personal monitor, our gold standard, can be replaced with a linear combination of 2 or 3 of the other three exposure estimates (I, O, GMOE). On days when an individual had spent a large proportion of his indoor time away from home, the predictive ability of the regression model was weak, as would be expected. However, for the subset of days on which the time spent indoors was only at home, the multiple correlation coefficient for the predictive model was 0.81. This finding has the potential for greatly reducing the costs of exposure monitoring in epidemiologic studies.

ENVIRONMENTAL MODELLING OF TOXIC SUBSTANCES IN SOUTHERN ONTARIO

Donald Mackay, Sally Paterson, Wan-Ying Shiu, and Christina Charles
Department of Chemical Engineering and Applied Chemistry
University of Toronto

Key words: Southern Ontario, Organics, Environmental Fate, Partitioning Model.

ABSTRACT

It is possible to develop methods of predicting the concentration of organic contaminants in the Southern Ontario Region from a knowledge of:

(i) the magnitude of local emissions to air, water and soil, both past and present;

(ii) the magnitude of advective inflows in air and water from other regions;

(iii) the physical-chemical properties of the chemicals as they influence partitioning tendencies between the media of air, water, soil, sediment and various biota;

(iv) the reactivity of the chemicals in these media which controls the chemicals' persistence; and

(v) the intermedia transport properties of the chemical, especially air-water, air-soil and sediment-water exchange.

A Level IV fugacity model has been devised which attempts to predict the time-dependent concentrations of specific chemicals in the Region from these input data. The model has been applied to a number of chemicals for which approximate emission data and prevailing concentration data are available. Reconciling the model with the prevailing concentrations requires comparison of the single predicted mean concentrations with a distribution of environmental concentrations in each medium. The Weibull distribution function has been found to be particularly advantageous. The principal difficulties are uncertainties about emission rates and prevailing concentrations.

If the model can be calibrated and validated, it could be an invaluable tool for exploring and documenting the behaviour of these contaminants, for elucidating dominant human exposure routes, for testing the effects of emission control measures and for determining, with the help of monitoring data, if a particular region is suffering from an unusually high concentration of a specific contaminant.

DIAGNOSTIC TESTING OF THE SWARU INSTALLATION IN HAMILTON

J. Trought[1], V. Ozvacic[2], and S. Thorndyke[3]
[1]IMET, [2]Ministry of the Environment, [3]Ontario Research Foundation

Key words: SWARU, Hamilton, Diagnostic Testing, Waste Incineration, Organics, Dioxins, PCBs, Stack Emissions.

ABSTRACT

The first measurements of the stack emissions of dioxins and furans at the SWARU installation were done in three tests in 1982, as part of a study progam on the formation of these species at municipal incinerators in Ontario. The test emissions were in excess of the limits set by the Provisional Guideline for stacks, and consequently, the plant was ordered to cut back on the refuse incineration rate. A comprehensive program, known as diagnostic testing, was carried out in 1983 to establish the limits for safe operation of the incinerator. The program was designed conceptually by the personnel of the Ministry's Air Resources and Laboratory Services Branches and contracts were let to Envirocon and the Ontario Research Foundation to work out the details and execute the field work.

The Ontario Research Foundation was responsible for the collection and preparation of stack and process stream samples for analyses on dioxins, furans, chlorobenzenes, PCBs and chlorophenols. The Laboratory Services Branch performed the analyses and the Air Resources Branch was responsible for co-ordinating the field work. Envirocon was responsible for process monitoring.

As a result of the study, new operating limits for incineration were established, maintenance procedures were modified, and installation of additional process gas monitors and of additional control equipment for the removal of particulates from the stack emissions were recommended.

CHEMICAL AND PHYSICAL CHARACTERIZATION OF AIRBORNE PARTICULATES AND THEIR SOURCES THROUGH MULTIELEMENT ANALYSIS AND RECEPTOR MODELLING

T. Glenn Pringle and R.E. Jervis
Department of Chemical Engineering and Applied Chemistry, and
Institute for Environmental Studies, University of Toronto

Key words: Particulates, Air Pollution, Multielement Analysis, Receptor Modelling.

ABSTRACT

Source identification and apportionment of ambient airborne particulates is important if air pollution is to be more stringently controlled in urban, industrialized regions. These are locations where traditional air pollution dispersion models are at a disadvantage because of the investment of time, funds and manpower required to diligently characterize all the major contributing emission sources. On the other hand, receptor models utilize measurements at just one or a few limited receptor sites, and the contributing sources are then statistically evolved by analysis of a set of data factors: detailed chemical composition of ambient particulates, meteorological data, particle-size distributions and site locations.

In this research, radioanalytical methods are being applied for the simultaneous analysis of about 30-35 chemical elements in airborne particulate matter sampled in the greater Metropolitan Toronto area during the period from January 1984 to the present. In the first one and a half years of the funded project, all the results obtained together with the relevant meteorological data were subjected to statistical factor analysis with the objective of deducing, from the multielemental chemical composition data itself, the major contributing sources of air pollution in the Toronto atmosphere. Factor analysis indicated that six sources were distinguishable: wind-blown soil grains, automobile exhaust, refuse incineration, winter road salt, oil combustion and an unidentified source of arsenic. Elemental concentration profiles for the several elements that characterized each of these six sources were input into a comprehensive chemical element mass balance calculation to determine quantitatively the relative contribution of each source to the ambient Toronto aerosol.

The results showed that re-entrained soil contributed 67% to the inorganic portion of atmospheric air particulate matter, automobile exhaust contributed 15%, road salt 12%, and the other sources lesser amounts. A limited additional study of particle-size distributions, especially for Al, Fe, Sc, As, Br, Cl, Zn, Mn and V, provided some additional details on aerosol characterization.

STUDY OF CONDITIONS FOR CONDENSATION AND DESORPTION OF PCDD ON PARTICULATE MATTER UNDER STACK SAMPLING CONDITIONS

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Key words: Incineration, Flyash, Dioxin, GC-MS.

ABSTRACT

Municipal incinerator flyash was heated in a pyrex tube under a flow of high-purity nitrogen. The levels of polychlorinated dibenzo-p-dioxins (PCDD) in the heated samples were determined using gas chromatography/mass spectrometry (GC/MS) and compared to levels in unheated samples.

In a time and temperature study where temperatures from 100° to 200°C and heating times from 16 to 48 hours were investigated, PCDD levels decreased to 10 to 30 per cent of the levels in unheated samples. The PCDD levels were independent of heating time and temperature under the above conditions. About 10 per cent of the PCDD could not be desorbed and are thought to be chemisorbed on the surface of the flyash particles. Heating the flyash at 120°C for 2 to 6 hours desorbed 15 to 38 per cent of the PCDD. The desorption rates for the PCDD congeners were estimated to be 0.037, 0.086, 0.15 and 0.23 ng/g/hr/L for tetrachloro-,pentachloro-, hexachloro- and heptachlorodibenzo-p-dioxins respectively. At constant temperature, these rates appear to depend mainly on the amount of the particular PCDD congener originally present on the flyash, not on physiochemical properties such as vapour pressure or dipole moment. When expressed as per cent/hr/L, desorption rates for the PCDD congeners were not significantly different from each other. The average value was 0.78 per cent/hr/L. Desorbed PCDD were adsorbed onto exhaustively extracted flyash placed in the tube downstream of the heated sample. There was no evidence of decomposition of the PCDD under the experimental conditions.

ASSESSMENT OF TOXICITY OF INGESTED AND INHALED HALOAROMATIC HYDROCARBONS

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Key words: Organics, Toxicity, Dioxins, Health Effects, Immunosuppression.

ABSTRACT

Previous studies in our laboratory have shown that 2,3,7,8-TCDD and related haloaromatic hydrocarbons such as Aroclor 1254 and 3,4,3',4'-tetracholorobiphenyl suppress the immune response. In the case of TCDD, suppression of the generation of cytotoxic T cells (CTL) occurred at a cumulative dose of 0.004 ug/kg (12 pM or 4 parts in 10^{12}) in chronically treated inbred laboratory mice. This immunosuppression proved to be 100-1000 times more sensitive an index of TCDD effect than was induction of hepatic P_T450 and related enzyme systems. Further, inhibition of CTL generation by TCDD was associated with an increased mortality following challenge with herpesvirus type 2.

Studies designed to elucidate the mechanism of immunosuppression by TCDD have shown that TCDD promotes the production of suppressor T cells. Sensitivity to TCDD is determined in part by genes at the Ah locus in mice and, using chimeric mice created by replacing the lymphocyte component of the immune system of TCDD-sensitive mice with cells from TCDD-resistant mice and vice versa, we were able to show that immunosuppression by TCDD is mediated through the non-lymphoid cells of the host. Since T cells develop in the thymus gland under the influence of thymic epithelium, and since epithelial cells have been noted to be particularly sensitive to TCDD, we proposed that TCDD acted via the thymic epithelia to promote suppressor T cell production.

Results from current studies have provided several new and relevant pieces of information:

1. Removal of the thymus gland from 6- to 8-week old mice renders them totally resistant to immunosuppression by low level TCDD exposure. The importance of the thymus is thus confirmed.
2. Thymus function declines with age. We found that 8-month old TCDD-sensitive mice that had achieved 20%-25% of their life span (roughly equivalent to a 15- to 17-year old human) were readily suppressed by 12 pM TCDD, whereas 13-month old mice that had completed approximately 36% of their life span (roughly equivalent to 22- to 28-year old individuals) and 22-month old mice were completely resistant to suppression by TCDD. These data have an interesting parallel in that in the study by Knutsen of humans exposed to 20 - 100 ppb for 2 years (or to 100 ppb for 6 months) in Time's Beach, Mo., evidence of immunosuppression was seen primarily in the group under the age of 18.
3. While TCDD administered orally in food has been shown to suppress CTL generation, a further experiment has indicated that a substantially greater amount of TCDD must be given orally to achieve the same immunosuppressive effects as 12 pM injected parenterally. A preliminary dose-response study suggests that the difference in oral vs parenteral dose required may be on the order of 1000 fold.

These data have significant implications for the setting of zero biological effect exposure limits for different groups of individuals who may be exposed to TCDD and related haloaromatic hydrocarbons by different routes. Further, since the thymus-mediated immunosuppressive effects appear to be reflected in alterations in the surface markers on blood T lymphocytes both in mice and in humans, it may be possible to monitor exposed individuals using a simple non-invasive technique.

THE RAPID SCREENING OF MUNICIPAL REFUSE INCINERATOR FLY-ASH AND STACK GAS FOR PCDD/PCDF USING A TRANSPORTABLE TANDEM MASS SPECTROMETER (GC/MS/MS) SYSTEM

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Key words: Refuse, Incineration, Flyash, Stack Gas, Dioxins, Furans, GC-MS.

ABSTRACT

The formation of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF) is strongly linked to the incineration of municipal refuse. To date, there has been no study which demonstrated clearly what, if any , incinerator operation parameter(s) this production correlates with. Part of the problem in determining such correlations is that testing for PCDD/PCDF is an expensive and time-consuming effort. This paper describes a rapid analytical approach using gas chromatography (GC) coupled to tandem triple quadrupole mass spectrometry (MS/MS). This combination has been demonstrated to be more specific than conventional GC/MS while requiring less time per analysis. Furthermore, the instrument used in the present work (the TAGA 6000E manufactured by SCIEX) is fully transportable, permitting it to be driven to the incinerator for rapid on-site PCDD/PCDF analysis. The analysis of fly-ash and stack gas will be described and analytical results compared to GC/MS analyses performed on the same samples.

BLOOD LEAD AND ASSOCIATED RISK FACTORS IN ONTARIO CHILDREN - 1984

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Key words: Blood Lead Survey, Lead Exposure, Environmental Health, Exposure Assessment, Air Pollution.

ABSTRACT

Lead exposure from the external environment as well as the home has received much attention in the past decade. In the absence of information on the blood lead levels of Ontario children who are not exposed to a known source of industrial emissions, the Ministries of Labour, Environment and Health undertook the Ontario Blood Lead Study. The purpose of this study was to determine blood lead levels in Ontario children and to identify those demographic, environmental and lifestyle characteristics related to higher blood lead levels.

1315 children aged 7 and younger in selected urban, suburban, and rural areas of Ontario were sampled for analysis of blood lead. Blood lead concentration was determined in finger prick blood samples by graphite furnace atomic absorption spectrophotometry. Measurement of lead in air where children live, lead in tap water at their school, and lead in soil in areas where they play was carried out. Traffic density was measured at the largest intersection nearest to the children's school. A random sub-sample of 800 families of children tested for blood lead was assessed for the presence of risk factors which may be associated with elevated blood lead concentrations.

Urban children had higher geometric mean blood lead levels (12.0 ± 4.4 ug/dl) than suburban children (10.0 ± 3.5 ug/dl), and they in turn had higher blood lead levels than rural children (8.9 ± 3.9 ug/dl), a statistically significant difference. 4.3% of all children were at or above the alert level of 20 ug/dl; the proportion above the alert level did not differ between urban, suburban and rural children. Blood lead levels were slightly higher for males than females and for pre-schoolers aged 3 and 4, compared to school age children aged 5 and 6. The distribution of blood lead levels among these children was lower than that of children in point source areas.

Multivariate statistical modelling resulted in a set of characteristics which best explained the differences in children's blood lead levels: younger age, lower family socio-economic status, hot water radiator heating in the home, number of gas stations within six blocks of residence, number of industries within six blocks of residence, residence within one block of a major highway, and geographic site (Toronto, Windsor, Etobicoke, Scarborough, Longwoods, Nanticoke-Walpole). Environmental measurements of lead in air and soil, together with neighbourhood traffic density, were equivalent to "geographic site" in their ability to predict variations of blood lead levels among children. These environmental measurements and neighbourhood characteristics were meaningful surrogates for "site" in being able to estimate the potential contribution to the lead burden of children.

Five of the seven factors most closely related to children's blood lead levels are measures of lead in the physical environment. The prime contributor to air lead in the areas tested was lead in gasoline. Reduction of lead in leaded gasoline may be expected to produce some reduction of blood lead levels in children in Ontario.

THE DISPERSAL OF AIR PARTICULATES ON A SHORT AND LONG-TERM TIME SCALE

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Key words: Particulates, Air Quality Monitoring, Multielement Analysis, Lead, Air Filters, X-ray Analysis.

ABSTRACT

Two streak filters, having a time resolution of 2 hours, have been used to monitor the air particulates near an intersection in Kingston over a two-week period in June. One filter was placed ~100 m from the intersection while the second was placed ~ 700 m away in the backyard of a home. The local meteorological conditions were determined with a micro-processor based weather station which formed part of the sampling device. Wind speed and direction, temperature, rainfall and humidity were sampled every 7 seconds and averaged over a half-hour so that the conditions under which the air particulates were collected were known.

The particulates on filters were analyzed for their elemental composition with particle induced X-ray emission (PIXE) using the Queen's Van de Graaff accelerator. Each filter contained a deposit for one week and two of these for the same week, one from each site, have been analyzed. Al, Si, S, Cl, Ca, Cr, Mn, Fe, Cu, Zn, Br and Pb were found in measurable quantities at both sites. The average levels for all the elements except Br and Pb were the same at the two monitoring sites, indicating that elements from natural sources and from fossil fuels are distributed uniformly in this region. Near the intersection, the ratio of Br to Pb was 0.21, indicative of automobile emission. In the backyard, the concentrations of Br and Pb were lower by factors of 4 and 2 respectively. As previously observed, high Pb concentrations (up to 0.6 ug/cm^2) correlate strongly with vehicular traffic especially for the station nearer the intersection. There is some indication that the wind velocity, as measured by the station near the intersection, can account for the difference in the high lead levels between the two stations although this is not completely clear. Further evidence for this will be obtained when the filters from the second week are analyzed.

DOSE-RESPONSE STUDIES OF GASEOUS POLLUTANTS ON FOOD CROPS

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Key words: Ozone, Agriculture, Food Crops, Air Pollution Effects.

ABSTRACT

Controlled environment ozone dose-response studies were performed on several food crop species using cultivars widely cultivated in Ontario. Two or three week old cabbage, carrot, and tomato plants were exposed to 0, 0.1, 0.2, or 0.3 ul/l for one 7-hour period. Two-week old "Cherry Belle" radish plants were used as the indicator species in the experiments. Immediately following exposure and also 3 days later, the plants were rated for injury. Three days following ozone exposure, leaf area and leaf and/or stem fresh and dry weights were measured where applicable. For carrot and tomato, significant negative linear dose-response relationships were determined for all growth parameters at both ages at all ozone levels. The reactions of cabbage to ozone differed according to age. The results of the 2-week old plant growth studies indicated a quadratic response to dose with no significant leaf growth reduction occurring until ozone reached 0.2 ul/l. However, no significant ozone effects were observed in the three-week old plants. Field studies in open-top chambers were conducted during the summer using the same species and treatment regimes to determine what type of comparison can be made between indoor and outdoor ozone studies.

Asparagus plants were subjected to the same ozone treatments as previously described. Frond and spear areas, and fresh and dry weights and injury were determined. No significant differences in growth were found. An experiment was performed using 2- and 3-week old carrot plants to determine dose-response to ozone at 0, 0.06, 0.12 or 0.18 ul/l for one 7-hour exposure. A significant ozone effect was observed at both growth stages with growth significantly reduced at 0.18 ul/l. A long-term study to determine ozone effects on carrot shoot growth and root productivity was conducted. Beginning at 16 days of age and once each week for 5 consecutive weeks, the plants were exposed to one 7-hour period of ozone (0, 0.06, 0.12, or 0.18 ul/l). Data analyses and interpretation of data have not been completed at this time, but will be by the time of the Technology Transfer Conference.

Two experiments were conducted with 2-week old tomato plants to determine if imidazolidinyl urea (IDU), a compound similar in structure to EDU, would serve as an ozone protectant. In one experiment, IDU levels of 0, 100, 500, or 2500 ug/ml were sprayed on plants 3 days prior to ozone exposure (0, 0.1, 0.2, or 0.3 ug/l). No evidence was observed for protection against ozone injury. A second experiment also indicated no protection from 0.2 ul/l of ozone with spray applications of 2500 or 10000 ug/ml of IDU applied 0, 1, or 3 days prior to exposure.

USE OF THE DIRECT SAMPLE INSERTION DEVICE FOR SAMPLE VAPORIZATION IN THE INDUCTIVELY COUPLED PLASMA FOR ATOMIC AND MASS SPECTROMETRY

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Key words: ICP-MS, Multielement Analysis, Sample Insertion Devices.

ABSTRACT

The Direct Sample Insertion Device (DSID) will be described, and its application in several areas will be discussed. For liquid samples, the wire loop DSID has demonstrated sub-ppb detection limits for both Atmomc Emission and Mass Spectrometry. Precision better than 1% appears to be possible using an automatic injection system developed in our laboratory. A number of advantages for both optical and mass spectrometry appear to be provided by the wire loop configuration. These include temporal resolution of possible interfering species and elimination of water vapours. The performance of the liquid wire loop DSID system will be discussed in some detail for both optical and mass spectrometric configurations. The systems will be compared and contrasted.

Solid sample introduction into the inductively coupled plasma for atomic emission spectroscopy will be discussed. Considerable success has been achieved with human hair. Undigested single hair samples have been inserted. Precision of the technique seems to be dependent on hair and not on the DSID for Cu. Some questions remain as to the applicability of the technique for high accuracy determinations; however, the accuracy is quite adequate for surveys. More difficult solid sample types will also be discussed.

IDENTIFICATION OF SELECTED PAHs IN A HAMILTON, ONTARIO AIR SAMPLE BY SHPOL'SKII SPECTROSCOPY

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and
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Key words: PAH, Trace Organics, Atmospheric Emissions, Shpol'skii Spectroscopy, Hamilton.

ABSTRACT

Shpol'skii Spectroscopy is used to establish the presence of selected PAHs, including both benzo(a) and benzo(b) pyrenes, in an air sample taken from the vicinity of steel refineries in Hamilton, Ontario. The selected PAHs are taken from a list of priority PAHs drawn up by the Ontario Ministry of the Environment. The sample analyzed is an HPLC fraction of a Hi-Vol sample provided by IEC Beak Analytical Services and is diluted with n-octane in preparation for analysis by Shpol'skii Spectroscopy. The dilute solution is flash frozen in liquid nitrogen and then cooled to 12°K. Preliminary identification is made by first obtaining a fluorescence spectrum of the environmental sample using a pulsed nitrogen laser at 337 nm as the excitation source and then comparing this with reference spectra from a library of fluorescence spectra of authentic PAHs in n-octane matrices. To confirm the tentative identification, use is made of excitation spectra of the environmental sample obtained with the aid of a pulsed tunable dye laser. The fluorescence from the sample is observed with a monochromator set at the wavelengths of individual fluorescence spectral features used to make the preliminary identifications. These excitation spectra are compared to reference spectra in a library of excitation spectra of authentic PAH samples in n-octane matrices. The final identification of PAHs in the environmental sample is compared with that obtained by HPLC analysis of the same environmental sample in the Ministry of the Environment's laboratories.

THE EXCHANGE OF AIR PARTICULATES BETWEEN THE INSIDE AND OUTSIDE OF A BUILDING

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Key words: Particulates, Air Quality, Multielement Analysis, Indoor-Outdoor Air.

ABSTRACT

The element composition of air particulates collected simultaneously inside and outside a school has been determined with particle induced X-ray emission (PIXE) using the Queen's Van de Graaff accelerator. The indoor stations were placed in three sections of a school which are ventilated separately and which are more or less isolated from each other, one a classroom, the second an office and the third a workshop.

The particles were collected on streak filters operating with a time resolution of two hours so that time correlations between the indoor and outdoor air could be monitored. Two filters at each position, each of one week duration, were collected. One indoor, from the classroom, and one outdoor filter from the same time period have been analyzed, and the other six filters will be analyzed shortly.

Al, Si, S, Cl, Ca, Cr, Mn, Fe, Cu, Zn, Br and Pb were observed both inside and outside the school. The levels of Al, Si, Ca, Br and Pb were all lower by a factor of 2 - 3 inside the school than outside, Cl appeared to be higher and the others the same. Besides Pb and Br which were expected to have elevated levels of short duration due to the traffic pattern at the intersection, several other elements showed high levels of short duration outside the school and so the exchange of air into and out of the building could be determined. If a high level appeared outside the school, an elevated level inside the school was measured within two hours, the time resolution at which the system was operated. The actual level inside the school was not always the same fraction of that which appeared outside the building and this is not understood. Generally, the level inside this classroom was about a third of that outside. Whether this is the same for the other locations will be determined when the other filters are analyzed.

FEASIBILITY OF DETERMINING SO_2 MASS EMISSION FLUXES BY STACKSCANNING

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Key words: Stack Emissions, Emissions Monitoring, Sulphur Dioxide.

ABSTRACT

The MONITEQ PLUMETRACKER has a proven record for being able to remotely measure SO_2 concentrations in overhead plumes several kilometers downwind of a stack. During 1984, with the assistance of the Ontario Ministry of the Environment, MONITEQ undertook a study to assess the feasibility of using a PLUMETRACKER from a stationary platform to measure SO_2 emissions at the mouth of a stack. A 5-metre high test stack normally used by the Ministry to train personnel to measure plume opacity was used for these investigations. Parameters studied included varying SO_2 concentrations, plume opacities, background sky conditions and the effects of the sun and sight elevation angles. The SO_2 concentrations exiting from the stack were verified using an in-stack continuous emission monitor (CEM).

The work established that there is a strong correlation between the CEM value and the PLUMETRACKER value, but that the nature of the correlation varied from experiment to experiment. The correlation desired is a linear, one-to-one relationship between the CEM measurement and the PLUMETRACKER measurement (as was obtained in an initial laboratory comparison). The field results obtained did yield linear relationships, but they showed three forms of variation from the ideal: an offset; a slope other than one; and scatter in the points. This behaviour is ascribed to several causes, including instrumental effects and those related to the experimental procedure.

The principal instrumental effect is believed to be caused by a variation in response within PLUMETRACKER's rectangular field of view. Such performance, if true, is not noticeable in the instrument's normal mode of operation wherein the angular extent of the plume (some distance downwind of the source stack) greatly exceeds that of the instrument's field of view (FOV), but is significant under the stationary conditions of this study wherein the plume size at the stack mouth is much smaller than the instrument's FOV. The effects of the other parameters under study were small in comparison to the aforementioned and it was therefore not possible to quantitatively determine their impact upon the measurement.

The study concluded that the PLUMETRACKER and the measuring technique can be modified to overcome the variable response problem of the PLUMETRACKER FOV. The proposed solution is to reduce the instrument's FOV and adopt a true scanning technique whereby the instrument's FOV is uniformly scanned across the mouth of the stack.

GAS PHASE PHOTOCHEMISTRY OF POLYCHLORINATED BIPHENYLS

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Key words: PCBs, Photodecomposition, Air Pollution, Contaminant Transport, Aromatic Hydrocarbons.

ABSTRACT

The quantum yields of photodecomposition of a series of polychlorinated benzenes and polychlorinated biphenyls have been determined in the vapour phase. Most of the compounds studied decompose with a photochemical efficiency in the range of 10 - 20%. By making use of literature data on typical ambient concentrations of PCBs in urban air, and literature data on the variation of the solar intensity with wavelength, it has been concluded that photodecomposition of these substances is very slow in absolute terms. Consequently, chlorinated aromatic hydrocarbons are able to travel through the atmosphere and to be deposited unchanged far from their point of emission into the atmosphere. These conclusions are in line with practical experience. Details of the methods used for the actinometry and for the calculations will be discussed.

A FUNDAMENTAL STUDY ON THE DEPOSITION OF AEROSOLS ON CYLINDERS IN TURBULENT CROSS FLOWS

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Key words: Aerosol, Deposition Rates.

ABSTRACT

The deposition of aerosols on non-streamlined surfaces such as cylinders and spheres in ideal flow (viscous or inviscid flow) has been studied in some detail. Under such flow conditions, the deposition process has been modelled in terms of the inertial impaction, interception and Brownian diffusion collection mechanisms. Carefully designed experiments to test these models have shown them to be adequate for the conditions under which they were developed.

However, recent experimental results on the deposition of aerosols on single wires in turbulent cross flow yielded significantly higher collection efficiencies than the values predicted by the classical mechanisms. To explain the increased collection efficiency, it is necessary to consider eddy diffusion of the particles due to the free stream turbulence as a prime mechanism.

Based on the concept of eddy diffusivity, a turbulent diffusion model has been developed to predict the experimentally observed deposition rates. The model is essentially the solution of the continuity equation and equations of motion for the particles, with the assumption that within the boundary layer the fluid-particles closely follow the fluid streamlines. From physical reasoning, the eddy diffusivity profile within the boundary layer is assumed to have the same shape as that near a flat plate.

The model equations are solved with the solution of the boundary layer equation in which the external flow is assumed to be for potential or for experimental flowlines. Computed deposition rates are in good agreement with the experimental results when the solution of the turbulent diffusion model is based on the solution of boundary layer equations where experimental flowlines are used for external flow instead of potential flow conditions. A single parameter, known as the turbulent Schmidt number, was obtained which adequately characterizes the system.

SESSION B

WATER QUALITY RESEARCH

TRACE ORGANIC CONTAMINANT REMOVAL FROM DRINKING WATER

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Key words: Water Treatment, Trace Organics, Drinking Water, Granular Activated Carbon, Great Lakes, Contaminant Removal.

ABSTRACT

More than 4 million Ontario residents rely on the Great Lakes as a source of drinking water. These surface bodies continue to be contaminated with organic chemicals of industrial and municipal origin, with over 200 man-made chemicals being identified recently in the Niagara River alone. Granular activated carbon is capable of removing many of these chemicals from drinking water supplies.

A pilot plant consisting of conventional water treatment processes plus granular activated carbon (GAC) adsorption contactors is being built to study the effectiveness of both conventional and GAC processes at removing trace levels of selected organic contaminants from drinking water. The pilot plant is located at the Niagara Falls Water Treatment Plant in Chippawa.

The removal of 35 organic compounds will be monitored at natural and at spiked influent levels. These compounds include: aromatics, halogenated aliphatics, chlorinated benzene derivatives, PCBs, organochlorine pesticides and herbicides, phenols, phthalates, polyaromatic hyrdocarbons, alkanes, alcohols, aldehydes, ketones and esters. Since these compounds are at trace levels, special methods have been developed for sampling, concentrating and analyzing water containing this mixture of chemicals at nanogram per litre levels and lower.

Start-up of the pilot plant will include a program to optimize the removal of the trace contaminants in the conventional section of the treatment process by testing a variety of coagulants, coagulant aids and operating conditions.

The pilot plant design, the analytical methods development and the start-up program are discussed.

PILOT TESTING PROGRAM FOR POTABLE WATER TREATMENT FOR COLOURED NORTHERN ONTARIO WATER

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M.M. Dillon Ltd.

Key words: Water Treatment, Colour Removal, Ozonation, Northern Ontario, Atikokan River.

ABSTRACT

This paper describes pilot testing of colour removal processes for raw water from the Atikokan River. Processes used during the testing program, which ran from Summer 1984 to Spring 1985, include:

- ozonation;
- ozonation followed by granular activated carbon adsorption;
- ozonation followed by alum coagulation and dual media filtration;
- alum coagulation and dual media filtration.

Ozone dosages up to 8 mg/L, combined with ozone contact times ranging from 2 to 20 minutes, reduced organic colour by approximately 50 per cent. Even at 8 mg/L ozone dosage, disinfection was not complete.

EBCTs ranging from less than one minute to over one hour were used in evaluating granular activated carbon (GAC). Increases in effluent SPC indicate biological growth on the GAC. No biological regeneration of the GAC was noted under the test conditions. Colour removal on GAC ceased before 7,000 bed volumes of water were treated.

Parallel direct filtration runs show that less coagulation (alum and polymer) are required when the water is pre-ozonated.

The alternative colour removal processes are evaluated on the basis of operating cost (at Atikokan) for colour removal to 5 H.U. The secondary consideration, reduction of trihalomethane formation potential to less than 350 mg/L, is met by all processes reducing organic colour to less than 5 H.U.

Process design for a new Potable Water Treatment Plant for the Township of Atikokan, using pilot testing results, is discussed.

DEFLUORIDATION OF AMABELLE TOWNSHIP GROUNDWATER

P.J. Halliday

Proctor & Redfern Limited

Key words: Deflouridation, Groundwater, Amabelle Township.

ABSTRACT

A study of groundwater deflouridation was carried out in August 1985. Two deflouridation processes were selected for evaluation after an intensive literature review. These were:

1. Activated Alumina
2. Reverse Osmosis

Activated Alumina is currently in use in the United States. However, very little data is available on the quality and quantity of regenerant waste produced by the process. Two types of regenerant were evaluated:

1. 1% NaOH Solution

2. Hanfloc (with an equivalent caustic strength to 1% NaOH)

Rapid advances have been made in membrane technology over the past ten years. Reverse Osmosis was evaluated to assess its degree of efficiency and throughput capacity.

The results of both pilot units will be presented, with cost estimates and operational requirements for treating the Amabelle Township ground water.

SEDIMENT AND POLLUTANT ACCUMULATION IN THE HUMBER RIVER MARSH, TORONTO, ONTARIO

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Key words: Humber River, Sediment, Contaminant Accumulation.

ABSTRACT

As part of the Toronto Area Watershed Management Strategy or TAWMS study, sediment and contaminant accumulation in the Humber River Marsh was evaluated. The study area consists of a low energy fluvial system bounded by Lake Ontario in the south and Bloor Street in the north. Sediment cores were collected from the channel, floodplain and backwater pond environments present in the Marsh during the fall of 1983, and laboratory analyses were performed during the fall of 1984 and spring of 1985.

Recent sedimentation rates as measured by stratigraphy, pollen and lead-210 radioisotope analysis ranged from as low as 0.2 cm/yr. on the floodplain to as high as 1.9 cm/yr. in the backwater ponds. Cores were subsampled and tested for specific trace metals, polychlorinated biphenyls (PCBs), and the pesticide DDT and its metabolites DDD and DDE. Metal concentrations ranged from below detection limit to 7, 108, 79, 970, 85, and 190 ug/g for Cd, Cu, Cr, Mn, Ni, and Pb, respectively. Organic pollutant concentrations ranged from below detection limit to 163.4, 65.0, 93.9 and 21.3 ng/g, respectively for PCBs , DDT, DDD and DDE.

With the exception of Pb in all cores and Cd in one core, metal contamination was not considered to be significant (i.e., surface metal concentrations were not significantly greater than assumed background levels). With respect to PCBs, DDT, DDD and DDE sediment contamination was considered to be moderate. It is estimated that approximately 3000 kg of lead, 3.2 kg of PCBs, 0.4 kg of DDT, 1.3 kg of DDD and 0.4 kg of DDE are presently stored in the Humber Marsh. In general, sediments from the backwater ponds had the highest contaminant concentrations, reflecting finer sediment texture and possible point sources of pollutants. The study indicates that contaminated sediments have been accumulating on the floodplain and in the backwater ponds for some time and, given present conditions, are likely to continue to do so. In general, the channel area does not represent a significant storage area for contaminated sediments. Further research into Humber River sediment quality is needed to monitor future changes in sediment quality and to pinpoint pollutant sources.

REGIONAL GEOCHEMICAL STRATIFICATION OF SHALLOW GROUNDWATERS RESULTING FROM CATCHMENT URBANIZATION

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Key words: Groundwater, Impact of Urbanization, Contaminant Migration.

ABSTRACT

Contact springs along the Scarborough Bluffs of eastern Metropolitan Toronto provide an ideal opportunity for studying the impact of urban development on shallow groundwater quality. Occupying 12 km of Lake Ontario shoreline, the Scarborough Bluffs represent an important discharge zone for a series of minor aquifers defined within the multi-layer sequence of tills, deltaic sands, and glacio-lacustrine diamicts. Within these deposits, a shallow aquifer system is recharged locally through areas which have recently been transformed from rural pasture to well populated commercial, industrial and residential areas. The deeper aquifer units form part of a regional flow system and are recharged primarily in rural parts of the extensive groundwater catchment.

A major ion, minor ion, trace metal and environmental isotope study of the spring waters reveals major differences in chemical character between the two systems. Groundwaters from the deeper aquifers are low in total dissolved solids and show many similarities to uncontaminated, low tritium and chemically mature waters from deep aquifers in the Duffin Creek-Rouge River drainage basins to the north and east of Metropolitan Toronto. By comparison, the shallow groundwaters reveal the effects of urban development and consistently display elevated concentrations of Ca, Na, NO_3 and Cl with average values of 155, 95, 35, and 200 mg/L respectively. These compare with average values of 70, 10, 5 and 10 mg/L respectively in the deeper waters.

Trace element concentrations of Cr, Co, Cd, Mo, Pb, Mn, Fe, Cu, Ni, Zn, Al and Hg in the spring waters exhibit considerable variability but several high anomalies are noted in the shallow, contaminated waters when compared to background levels determined in rural parts of the groundwater catchment. Since these elements may provide insight to contaminant source origin, complementary investigations are being conducted involving drilling and pore water extraction and analysis at sites where specific types of contamination are suspected. For example, vertical profiles of pore water chemistry from the unsaturated zone adjacent to major salted highways show Cl concentrations up to 14,000 mg/L and provide a range of diagnostic chemical criteria that can be used to confirm suspected road salt contamination in disputed situations.

THE EFFECTS OF TILE DRAINAGE AND OPEN DITCHES ON PEAK FLOWS AND DRY WEATHER FLOWS

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Key words: Agricultural Drainage, Tile Drainage, Hydrologic Simulation.

ABSTRACT

The project is scheduled for a three-year period and has been designed to assess the effects of tile drainage and open ditches on peak flows and dry weather flows with particular application to Ontario. This study involves (I) the development, calibration and testing of a continuous, physically-based, hydrologic simulation model for tile-drained agricultural fields and basins; (II) instrumentation of tile-drained fields in the South Nation River Basin; and (III) statistical analysis of (a) historical data from ditch and tile-drained fields and basins in the South Nation River basin and elsewhere, and (b) simulated discharges generated by the model developed in (I) above, both on a peak flow and a dry weather flow basis.

The project is presently 8 months into year 1 of its three-year schedule. A worldwide literature survey has resulted in the production of an annotated bibliography for the hydrology of agricultural drainage. Over 400 abstracts covering the period 1970-84 have been collected, catalogued and entered in a database using dBASE III. It is available both in hard copy and on IBM-PC compatible disks.

A physically-based hydrologic simulation model for tile-drained agricultural fields has been developed for the simulation of tile drain discharge under single rainfall events. The model is now being tested and calibrated. Instrumentation has been installed in a tile-drained field to collect rainfall and discharge data over the fall of 1985 for analysis during year 2 of the project.

PRE-FEASIBILITY STUDY ON EXPANSION AND UPGRADING OF PORT DOVER SEWAGE TREATMENT PLANT

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Cris Papadopol, Ontario Tree Improvement and Forest Biomass Institute,
Ministry of Natural Resources

Key words: Port Dover, Sewage Treatment, Activated Sludge, Biological Contactors, Aeration Devices, Tree Farm, Lagoons, Effluent.

ABSTRACT

The existing Port Dover Water Pollution Control Plant is a primary plant with phosphorus removal and has been subject to a number of operating problems during the last few years. A study was commissioned to review these problems and evaluate a number of options for expanding and upgrading the plant to provide secondary treatment.

The following options were considered:

- Conventional Activated Sludge
- Rotating Biological Contactors
- Biological Aerated Filters
- Extended Aeration, and
- Tree Farm

Two of the options considered are innovative concepts which have not been used in plants in Canada to date. The first is the biological aerated filter, marketed by Envirotech. It consists of a steel tank filled with fired clay media. Effluent is introduced at the top of the media, the upper section of which accomplishes biological treatment, and the lower section of which acts as a clarifier. The major advantage of this system is the low space requirement, and the fact that no secondary clarifiers are required, thus saving considerable capital cost.

The tree farm design involves storing sewage in a lagoon system and spray irrigating a tree farm with the effluent. In this manner, nutrients in the effluent enhance growth of the trees, and evapotranspiration from the leaf surfaces disposes of all of the effluent produced. This system has the added benefit of producing a valuable by-product, as the fast growing poplar and willow in the tree farm could be harvested as an energy crop every few years.

Capital and operating costs, and benefits of each system are outlined and a present worth analysis covering a 20-year period is performed as part of the analysis.

THE EFFECTS OF WASTEWATER QUALITY ON ULTRAVIOLET LIGHT DISINFECTION

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Key words: Wastewater Quality, Sewage Treatment, Disinfection, Ultraviolet Light Irradiation.

ABSTRACT

Although the ultraviolet light irradiation of treated wastewater has been accepted as a disinfection method, many of the effects of wastewater quality on this process have not been studied at the full scale level.

A full scale gravity flow UV system was placed in the effluent channel of a conventional secondary wastewater treatment plant. The system consisted of a series of modules forming two separate rectangular matrices of UV lamps.

Disinfection is a function of the intensity of UV light and the time of irradiation. The intensity is determined by the lamp output and the UV transmission of the effluent. A UV absorbing compound will be added to the effluent to determine the effect of intensity on disinfection efficiency before and after photoreactivation and will also determine when the UV lamps should be replaced. These experiments will verify that the UV sensor responds linearily to UV transmission. The response of the sensor will then be verified by using the various mathematical models which predict UV intensity and dosage.

The effect of suspended solids in primary and secondary solids may have the most significant effect on the efficiency of disinfection due to the protection of bacteria from UV light. Varying amounts of the three effluents will be mixed with high quality secondary effluent to determine the bacterial reductions before and after photoreactivation. These experiments will be repeated at the mid-point and end point of lamp life to establish the effective lamplife for different qualities of wastewater.

Photoreactivation accounts for the greatest increase in bacterial numbers after UV disinfection. The effect of UV transmission and/or suspended solids on this phenomenon will be studied. The irradiated bacteria will be exposed to various stream conditions and sunlight while they are in glass bottles and an irradiated tracer organism will be exposed to the sunlight and the receiving stream at the same time.

This study will determine whether a correlation exists between E. coli or bacteriophage and the pathogens which may remain in the UV disinfected wastewater. Bacteriophage can be enumerated in as little as four hours and this would serve as a rapid indicator of UV disinfection.

The current mathematical models' ability to predict the dosages within this UV reactor will be compared to actual bacterial reductions to develop design criteria for the UV reactor and various wastewaters.

THE TECHNICAL AND ECONOMIC FEASIBILITY OF RETROFITTING EXISTING MUNICIPAL TREATMENT PLANTS IN CANADA FOR BIOLOGICAL PHOSPHORUS REMOVAL

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Key words: Sewage Treatment, Phosphorus Removal, Activated Sludge.

ABSTRACT

The technical and economic feasibility of retrofitting existing wastewater treatment plants in Canada for biological phosphorus removal was evaluated, with the objective of establishing the type and size of facilities which would be most amenable to implementation of these technologies. The cost analyses were based on model treatment plants having idealized configurations representative of standard design practices. Effluent total phosphorus limits of 1.0 mg/l and 0.3 mg/l were imposed on the processes for the purposes of the cost comparison.

The technical review demonstrated that the four biological phosphorus removal (EBPR) processes evaluated - Bardenpho, UCT, A/O and Phostrip - were capable of producing a final effluent containing between 1.0 and 2.0 mg/l total phosphorus. To consistently achieve effluent phosphorus limits of less than 1.0 mg/l, EBPR processes require some combination of effluent filtration and/or supplemental chemical addition. Further, it was found that ideally, EBPR and chemical phosphorus precipitation processes should be considered to be complimentary processes which should be applied simultaneously to optimize performance and minimize the costs of achieving phosphorus control.

EBPR processes typically involved higher capital investment than chemical precipitation in retrofit situations. However, in conventional activated sludge plant retrofits at a hydraulic capacity of 36.4 Ml/d, the annual O & M costs of all EBPR options with the exception of Phostrip were lower than the O & M costs of chemical precipitation. Financing the higher capital expenditures associated with EBPR processes resulted in generally higher total annual costs for these processes than for chemical precipitation. Only A/O was more cost-effective than chemical precipitation based on total annual costs in any of the retrofit situations evaluated.

In new facilities, conventional activated sludge plants incorporating simultaneous chemical precipitation for phosphorus removal were more cost-effective based on total annual costs than all EBPR processes except A/O. On the basis of annual O & M costs, A/O was generally more cost-effective than the conventional plant, and when a 0.3 mg/l effluent total phosphorus limit was imposed, all EBPR processes except Phostrip had lower annual O & M costs than the conventional plant at a hydraulic flow of 13.6 Ml/d or more.

Conventional activated sludge plants of hydraulic capacity in excess of approximately 14 Ml/d were found to be most amenable to EBPR process retrofits based on the economic evaluation. However, factors such as the existing effluent nutrient limits imposed on WPCPs, the design of existing facilities and the characteristics of wastewaters in Canada combine to limit the number of candidates for retrofit of EBPR technologies. Circumstances which would lead to more widespread implementation of EBPR processes include the imposition of more stringent phosphorus and nitrogen removal requirements, major increases in chemical costs and the development of a greater level of confidence in the performance of EBPR processes.

THE ASSESSMENT OF A POINT SOURCE DISCHARGE OF SUSPECTED MUTAGENIC AND CARCINOGENIC CONTAMINANTS: AN EPIDEMIOLOGICAL APPROACH

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Key words: Mutagenicity, Carcinogenicity, Genotoxicity, Epidemiology, Neoplasia, Fish, Hamilton Harbour.

ABSTRACT

This study was undertaken to correlate genotoxicity with variations in the incidence of neoplasia in wild fish populations. The frequency of genotoxic lesions in adults and embryos has yet to be determined. The frequencies of grossly visible "tumours" are reported for White suckers (Catostomus commersoni) from Lake Simcoe and Hamilton Harbour, as well as Brown bullheads (Ictalurus nebulosus) and Carp (Cyprinus carpio) from Long Point Bay and Hamilton Harbour.

White suckers had lip and skin tumours, as well as hyperplastic skin. A smaller number of liver and other tumours was also present. Fish from Hamilton Harbour had a 58.3% incidence of external lesions, versus 29% in the fish from Lake Simcoe. 14% of the fish from Hamilton Harbour had liver "lumps", 25% lipid changes, and 6.3% intestinal bumps, the fish from Lake Simcoe having frequencies of 21, 7, and 11.6% respectively.

Gonadal tumours were present in 4/5 of the carp/goldfish hybrids from Hamilton Harbour, versus 18/35 from Long Point. No other abnormalities were noted in these fish.

Bullheads possessed both external and liver abnormalities. External growths were present in 14% of the fish from Long Point, versus 48% in the fish from Hamilton Harbour. The only difference internally was a 7% frequency of liver lumps in fish from Hamilton Harbour, while none were present in the fish from Long Point.

Histological confirmation of this data is necessary before any valid conclusions can be made; however, a hypothesis that the fish from Hamilton Harbour are affected by carcinogenic contaminants appears to be reasonable, possibly in association with some other as yet undetermined factors. It remains to be seen whether such observations are of value in predicting the impact of carcinogenic/genotoxic chemicals on feral fish populations.

DEVELOPMENT OF PREDICTIVE ORGANIC CONTAMINANT STRUCTURE-PROPERTY-TOXICITY RELATIONSHIPS FOR AQUATIC ORGANISMS

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Key words: Toxicity, Organics, Aquatic Organisms, Hazardous Contaminants.

ABSTRACT

Aquatic ecosystems and water supplies are exposed to a large number of organic contaminants. Traditional chemical-by-chemical toxicity testing methods are often too slow and expensive to permit all chemicals to be tested. Thus there is an incentive to estimate or predict toxicity from chemical structure using Quantitative Structure Activity Relationships (QSARS).

In this study, acute lethal toxicity tests are being conducted with two small crustaceans, Daphnia Magna and Artemia, and the results are correlated with the chemicals, properties and structure. The chemicals studied include PCBs, chlorophenols, chlorobenzenes, hydrocarbons, and series of nitrogen and sulfur heterocyclic aromatics and polynuclear aromatic hydrocarbons.

The results obtained indicate that the acute toxicity of non-polar organics is primarily controlled by the organism-water partitioning characteristics of the chemical, which is a reflection of aqueous solubility. Mathematical descriptions of this partitioning-toxicity phenomenon are being developed which, it is hoped, will find application to the prediction of the toxicity of various chemicals.

In a complementary study, the photo-induced toxicity of anthracene to Daphnia has been investigated. The results indicate that the primary toxicant is an active (probably free radical) species formed in or on the organism.

THE SIGNIFICANCE OF NEOPLASIA IN FISH POPULATIONS

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Key words: Neoplasia, Fish, Fish Cancer.

ABSTRACT

Our primary goal is to undertake an initial review of environmentally associated cancers in wild fish populations, and to review the evidence that such neoplasms are causally linked to environmental pollutants. Specifically, we wish to determine the extent to which alternative genetic and infectious causes have been considered. We also plan to consider why many other species of fish exposed to the same polluted environment do not exhibit cancers to the extent seen in those affected fish which receive most investigative attention. Other goals are to characterize early precancerous tissue pathology in target species and to determine the biochemical basis of the high susceptibility to liver tumors in some fresh water fish.

EPIDEMIOLOGICAL STUDY OF DISEASE INCIDENCE AND RECREATIONAL WATER QUALITY AT SELECTED CONSERVATION AREAS IN SOUTHERN ONTARIO

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Key words: Epidemiology, Water Quality, Bacterial Pollution, Ontario Beaches.

ABSTRACT

Results of two separate prospective epidemiological surveys at Ontario beaches have shown that morbidity rates are higher among swimmers than among non-swimmers. Swimmers have been shown to experience respiratory ailments most frequently followed by gastrointestinal, eye, ear, skin, and allergenic symptoms.

Concomitant with the epidemiological surveys, water samples were collected at the beaches and analyzed for total staphylococci, heterotrophic plate count, fecal coliforms, Escherichia coli, fecal streptococci, enterococci and Pseudomonas aeruginosa. In all investigations of this nature carried out thus far, correlations between bacterial levels and incidence of illness among swimmers and non-swimmers have been calculated for single organisms only. For example, on our first survey, morbidity among swimmers was shown to be related to staphylococcal counts ($p < 0.001$), to fecal coliform levels ($p < 0.001$) and to fecal streptococcal counts ($p < 0.016$). In this study, combinations of organisms such as E. coli, total staphylococci, and P. aeruginosa will be incorporated into the multiple regression analysis in various mathematical combinations, to determine if multiple indicators will be more appropriate as water quality parameters. Computer analyses are currently being carried out on the data.

FINGERPRINTING THE TORONTO WATERFRONT: A METHOD FOR DETERMINING THE SOURCES OF BACTERIAL POLLUTANTS

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Key words: Ontario Beaches, Lake Ontario, Fecal Contamination.

ABSTRACT

Utilizing restriction endonucleases, a method of "gene fingerprinting" has been devised. As a molecular epidemiologic tool, the method has important applications in establishing specific epidemiological criteria such as defining the sources and routes of transmission of infectious agents.

We have applied the method to outstanding questions related to bacterial pollution at the Toronto waterfront. Using total DNA extracted from Streptococcal organisms isolated from the feces of different animals, humans, water and sediments, we have attempted to correlate and match the gene fingerprints from the different sources. In this manner, we have attempted to establish the sources of, and thus the major contributors to, the overall bacterial pollution prevalent at the waterfront.

At present, the comparison and evaluation of differences and similarities in the hundreds of gene fingerprints studied to date has been performed manually by the investigators. We have tested a number of densitometric devices but their resolution capabilities are insufficient for distinguishing the multiple banding patterns obtained by gene fingerprinting. An alternative method has been studied which utilizes a system for automated computer-assisted analysis of gene fingerprinting data. We will describe a program that allows one to use a small computer equipped with a graphics tablet to scan a gene fingerprint by either wet-gel UV-illumination or white light illumination. The fingerprints are stored in a form in which they can be used later to compile similarities and differences as they relate to the different sources of the pollution.

Our manual results to date have indicated that gene fingerprinting is an extremely powerful tool that is only hampered by the time it takes to match and compare volumes of data over time. For example, geese contain many unique strains of fecal Streptococcal organisms, as determined by their unique gene fingerprints, although there are several "families" of these organisms which are extremely common among the geese populations. Furthermore, several of these common families are also present in water and sediment samples collected in and around the Western beaches area, suggesting that geese contribute significantly to the overall prevailing bacterial pollution. We are also developing DNA probes specific to the fecal Streptococcal organisms isolated from both human and non-human sources in order to provide a more sensitive, specific and rapid means of tracing sources and to quantitatively determine the total contribution of each source to the overall bacterial pollution present at the Toronto waterfront.

VALIDATION AND A POSSIBLE RE-ASSESSMENT OF CLAM CAGING EXPERIMENTS USING ELLIPTIO COMPLANATUS AS BIOMONITORS FOR TOXIC CONTAMINANTS IN WATER

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Key words: Clams, Biomonitoring, Toxic Contaminants, Bioaccumulation, Great Lakes.

ABSTRACT

A set of experiments was undertaken to examine the effects of cage design on the uptake and purging of toxic contaminants by the freshwater mussel Elliptio complanatus. Three types of enclosure apparatus were used to obtain comparisons of bioaccumulation rates at four Lake St. Clair sites, representing a wide range of toxicant levels (with respect to PCBs, OCS, lead and cadmium). The enclosures included wire cages (in standard use by MOE), circular corrals 1.25 m in diameter (each containing 5 clams) and clams, tethered to a transect with monofilament line. Another freshwater mussel, Lampsitis radiata siliquoidea, which is native to all Great Lakes, was compared to Elliptio by replicating each treatment.

The study clams were obtained from Balsam Lake, Rosedale, Ontario (for Elliptio) and Anchor Bay, Lake St. Clair (for Lampsilis). Clams and sediment samples were taken from each location where enclosures were deployed and from clam collection sites to determine background levels. The effect of sediment on toxicant uptake was examined using purified sand in half of the corrals.

The first set of clams was deployed in early June and recovered after a 46-day period. A second set of animals was deployed during the first week of September to make possible the examination of seasonal variation in contaminant uptake. Other aspects under study include sexual variation and the effect of varying exposure time on bioaccumulation of toxic contaminants by unionid molluscs.

REVISED MONITORING SCHEME FOR PERSISTENT AND TOXIC ORGANICS IN GREAT LAKES SPORTS FISH

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and
G.A.V. Rees and G. Crawford, Ontario Ministry of the Environment

Key words: Toxic Organics, Great Lakes, Fish Analysis, Persistent Organics.

ABSTRACT

A monitoring program for the identification and quantification of semi-volatile, persistent and toxic organic contaminants has been undertaken on selected samples of sports fish from the Great Lakes. The analytical methodology employed cold acid dissolution of the tissue, partition of the organics into solvent, followed by Gel Permeation Chromatography for the removal of lipid materials, and finally, full scan gas chromatographic/mass spectrometric (GC/MS) analysis. In addition to this analysis, negative ion chemical ionization (NCI) GC/MS analyses were also performed to provide enhanced sensitivity for halogenated organics below the ~50 ng/g (ppb) detection limit achievable by full scan electron impact GC/MS.

Samples of various fish species were collected from near-shore and open-lake areas of Lake Ontario, Lake Erie, Lake St. Clair, Lake Huron and Lake Superior. Summary data will be reported for the fifty samples analyzed and specific conclusions and recommendations based upon these data will be presented.

DEVELOPMENT OF A COST EFFECTIVE PROTOCOL FOR ROUTINE ANALYSIS OF TRACE ORGANIC CONTAMINANTS IN MUNICIPAL WPCP RAW SEWAGES AND FINAL EFFLUENTS

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Key words: Trace Organics, Sewage, Analytical Method, Effluent, Wastewater.

ABSTRACT

A novel analytical method has been developed for routine monitoring of trace organics in municipal wastewater. The prime objective of this work was to design a highly efficient protocol to ensure maximum sample throughput and to provide the required accuracy, sensitivity and reliability for such analyses.

Two methods were proposed and investigated in this study, which included the thermal stripping technique and the simultaneous in-situ acetylation and extraction method for bases, neutrals and phenolic compounds. The extraction performance was based on the results from a target list of chemical parameters chosen to represent various classes of compounds using organic free water, WPCP raw sewage and final effluents as test substrates.

The in-situ acetylation and extraction method was selected after preliminary investigation due to its ease of sample processing. The recoveries of the parameters and their corresponding coefficient of variation proved that the overall protocol was comparable, or in most cases, better than the EPA method 625. Some of the advantages of this method are:

- Rapid one-step extraction and derivatization
- No clean-up required
- Better recoveries for phenolic compounds and organochlorine pesticides
- Reduced fatty acid interference
- Better chromatography for phenolic and amino compounds.

All analyses were performed using a gas chromatograph coupled with a mass selective detector. Customized software was developed to generate multiple reports from a single analysis and to improve the autosequencing flexibility in sample processing and interpretation.

ANALYSIS OF CHEMICALS USED AT WATER TREATMENT PLANTS

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Key words: Organic Analysis, Water Treatment Chemicals, GC-MS.

ABSTRACT

The objective of this study was to develop analytical methodology for the isolation and identification of trace organic contaminants present in inorganic water treatment chemicals. This work included the development of extraction techniques in which the organic compounds are separated from the largely inorganic sample matrix. Further separation and identification of the organic compounds in the final extracts was carried out using combined gas chromatographic/mass spectrometric techniques.

A wide variety of the chemicals most commonly used in the water treatment process were studied. These chemicals are used in processes such as coagulation, pH adjustment, corrosion control, water softening, and fluoridation. The chemicals studied were classified into two distinct groups, each of which required a different extraction procedure. Solid samples were extracted using Soxhlet extraction techniques, while sample preparation for the aqueous solutions involved liquid-liquid extraction with a suitable organic solvent.

Compound identifications were made using GC/MS techniques in which two ionization modes were employed. Electron impact ionization was used for obtaining structural information, while chemical ionization using methane as the reagent gas was used for molecular weight determination.

The organic contaminants which were identified consisted of compounds such as: straight-chain alcohols, carboxylic acids, and alkenes; aliphatic and phthalate esters; cyclic ketones, alcohols, and alkenes; phenolic compounds and other substituted aromatic compounds; and compounds containing nitrogen and/or sulphur. The majority of these contaminants are simple hydrocarbons, while chlorinated species are virtually absent with only three identified. The total organic content in the chemicals studied was found to range between 0.01 and 300 ppm, with the majority of these samples containing less than 10 ppm of organic contaminants.

SESSION C

LIQUID AND SOLID WASTE RESEARCH

HAZARDOUS ORGANIC CHEMICALS IN GROUNDWATER AT ONTARIO LANDFILLS

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Key words: Hazardous Organics, Organics, Groundwater, Landfill.

ABSTRACT

Research in 1984/85 has concentrated on the occurrence and migration of organic contaminants at three landfill sites to determine the hydrogeological, geochemical and microbiological controls on the contaminant distributions. The North Bay and Woolwich plumes occur in stratified sands and the New Borden plume occurs in sandy silts. Emphasis has been placed upon the relatively mobile organics at these sites, namely chlorinated one- and two-carbon compounds and monoaromatics (benzene and substituted benzenes).

The New Borden plume extends laterally about 150 m from the site and trace organic contaminants extend, rather sporadically, throughout at least 100 m. Concentrations are temporally variable. Individual organics are usually less than 1 ppm in the landfill and less than 100 ppb in the groundwater.

Temporally and spatially variable organic distributions characterize the other plumes as well. Identifying the cause of this variability is the current emphasis at these sites. Variable input of contaminants from the landfill to the groundwater system exerts a major, but not exclusive, control. Detailed coring has been undertaken with the development of a reliable coring method. This permits the detailed hydrostratigraphic/hydrogeologic studies required to evaluate the influence of variations in flow patterns upon the organic distributions. The contributions of variable sorption properties and biodegradation rates to the variability in contaminant distribution are also being evaluated.

In addition, some unexpected biotransformation is suspected within the plume at North Bay. Anaerobic degradation of xylenes and trimethyl benzenes is apparent, for example, and so biotransformation processes are being evaluated with representative laboratory experiments.

THE ACCURATE DETERMINATION OF IN-SITU CONCENTRATIONS OF VOLATILE HYDROCARBONS IN GROUNDWATERS AT THE GLOUCESTER LANDFILL SITE, OTTAWA, ONTARIO

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Key words: Landfill, Leachate, Groundwater, Volatile Hydrocarbons, Gloucester, Contaminant Distribution.

ABSTRACT

The Gloucester Landfill is located near Ottawa, Canada, on a northeast trending ridge of Quaternary age. The ridge comprises a confined aquifer, overlying bedrock, and an unconfined aquifer separated by a silt unit which is an effective aquitard. Two independent Special Waste plumes have previously been identified at the Gloucester Landfill: the southeastern plume, migrating in the confined aquifer, and the northeastern plume, migrating in the unconfined aquifer. The distribution of volatile organic contaminants at the northeastern plume site was examined employing a new sampling technique which used polypropylene syringes as the collection and storage vessels, and a peristaltic pump to bring the leachate to the surface. Laboratory and field evaluations of this method have shown that the syringes are poor storage containers, and losses (≈10%) of some volatiles occur when sampling takes place through a peristaltic pump. Whether these losses are due to interactions with the tubing, or the suction of the pump bears further investigation.

Groundwater velocity measurements taken across the study area varied considerably (< 1 cm/day to 14 cm/day), indicating that the heterogeneities of the surficial sand unit are an important factor in contaminant migration.

Acetate ion was the only identifiable organic acid anion present in the leachate, and is measurable only in areas where the Special Waste contamination is significant. The distribution of volatile organic contaminants and inorganic anions seems to be related principally to the disposal history of the site, and the variable velocity of the groundwater. Sorption interactions are not well described by existing models, possibly because the organic content of the sediment is low (< 0.1%).

DESIGN OF GROUNDWATER MONITORING PROGRAMS FOR WASTE LANDFILL SITES

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Key words: Computer Model, Landfill, Groundwater Monitoring, Leachate.

ABSTRACT

A mathematical decision model, incorporating sampling costs, data variability, remedial action costs, and the probability of contamination, has been developed for aiding the design of groundwater monitoring programs. The monitoring program is for detection-type monitoring concerned with observing significant changes in water quality, and where remedial action is initiated upon detection. The tradeoff between periodic monitoring cost and the increased remedial action costs resulting from undetected plume growth is expressed mathematically. The effect on the expected value of the total cost of monitoring and remedial action by decision variables, such as the frequency of monitoring, is investigated.

AN IN-SITU METHOD FOR DETERMINING RATES OF DENITRIFICATION IN GROUNDWATER

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Key words: Denitrification, Groundwater, Nitrates.

ABSTRACT

A survey of nitrate concentrations in unconfined aquifers of Southern Ontario showed that in areas with shallow water tables, nitrate contamination was generally limited to shallow depths below the water table. With the water table at greater depths, nitrates were found to occur at greater depths in the aquifer. The observed distributions have been attributed to the occurrence (or lack of occurrence) of denitrification, and it has been suggested that the extent to which denitrification occurs depends upon the availability of organic carbon.

Previous studies have shown denitrification to be an important process in some aquifers; however, its occurrence is not entirely predictable, and the limiting conditions in the areas where denitrification does not occur are not known. An in-situ method for determining rates of denitrification in groundwater was developed. A column is installed in the field through the centre of hollow-stem augers. Water is withdrawn from the tester, nitrate, chloride and acetylene are added and the solution is re-injected. Chloride acts as a conservative tracer, while acetylene serves as a denitrification block, allowing samples to be analysed for nitrous oxide, to give a positive indication that denitrification is occurring. By determining the rate of nitrate loss, or the rate of increase in N_2O, rates of denitrification can be determined. In addition, nutrients, organic carbon or other additives can be used in the injection water to determine their effect on the denitrification process. The device also appears to have potential for the in-situ study of other biochemical processes such as biodegradation of organic contaminants.

SELECTION OF AERATION DEVICES

J.J. Ganczarczyk

J. Ganczarczyk & Associates

Key words: Aeration Devices, Activated Sludge, Sewage Treatment.

ABSTRACT

Selection of aeration devices for activated sludge treatment plants is usually made on the basis of the equipment costs and the basic technological factors: oxygenation capacity and oxygenation economy (energy consumption) values provided by the manufacturers of these devices. The mixing characteristics and the replacement and maintenance requirements for these devices are taken into consideration less often. Environmental factors such as stripping and cooling abilities, formation of aerosols, and noise generation are only occasionally analyzed. All of these latter factors, in addition to their technological meaning, are related to the health problems of operational personnel at wastewater treatment plants, and of communities in the vicinity of the plants. This study presents a comprehensive and systematic analysis and evaluation of all aspects of aeration devices to facilitate the selection of these devices for specific application. A review of the problems associated with different aeration systems is given and a "checklist" for selection of aeration systems is formulated. The proper selection process of aeration devices for a specific activated sludge treatment facility should be a multi-stage exercise, including (a) client preferences and analysis of the selection restrictions due to local factors and factors arising from the plant design; (b) equipment pre-selection on the basis of energy and capital cost considerations; (c) detailed analysis of technological factors involved in the operation of the aeration devices considered (oxygenation capacity, oxygenation economy and mixing performance); (d) detailed analysis of environmental factors (stripping, aerosol formation, cooling, and noise generation); and (e) final and comprehensive cost analysis of acceptable aeration systems, comprising elements added to correct or improve the technological and/or environmental performance of the devices. Each stage of the selection process will alter the preferences among the available devices and will shorten the list of these devices, but the last stage will bring the final recommendations.

COMPOSITION, MINERALOGY, AND MORPHOLOGICAL NATURE OF INDUSTRIAL WASTES AND THEIR LEACHIBILITY

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Key words: Industrial Waste, Leachibility, Waste Stabilization, X-ray Analysis, Electron Microscopy.

ABSTRACT

The composition and nature of a solid waste must be known in order to predict the leachibility (stabilization) of the waste under a variety of environmental conditions. Whereas the more traditional leach test reveals the mobility of a substance under only the testing conditions, knowledge of the binding of the metal to the solid substrate permits the calculation (and confirmation by testing) of metal mobility under any postulated environment. In addition, knowledge of other solid material may be important to the reactivity of the waste by setting up various chemical buffers, impeding permeation, etc.

This research, in its initial stages, considers the characterization of industrial waste (in order) from its composition, the chemical partial extraction of certain metals, its mineralogy, its morphology, and the specific association of metal to substrate at the micrometer scale. The overall major and minor element composition is obtained by X-ray fluorescence and instrumental Neutron Activation Analyses. In addition, loss on ignition, total sulfur, and organic/inorganic carbon are analyzed. The sequential extraction follows that of Tessier et al, and operationally defines the metal concentrations associated with ion exchangeable, carbonate, Fe/Mn oxides, organic, and residual phases. X-ray diffraction analysis is used for major elemental analysis to reconstruct the crystalline compounds. Both Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) are used to morphologically characterize the waste as to size and crystallinity, and to confirm the mineralogy and association of metal and solid. Computer-aided elemental mapping of images with respect to mineralogy further confirms the association of metal and solid substrate. Other follow-up measurements include surface area by the BET technique.

An industrial foundry waste, a plating waste, and a coal waste are used as examples to illustrate the above techniques and the strengths and weaknesses of each procedure. Then some proposals for stabilizing the wastes are developed using the accumulated information on the metal-substrate associations.

MODELLING THE MOVEMENT OF VAPOURS FROM HAZARDOUS LIQUIDS IN SOIL

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Key words: Hazardous Spills, Soil Contamination, Vapours.

ABSTRACT

The discharge of hazardous liquids to soil, either intentionally or by accident, has been the subject of much concern in recent years. Attention has focussed upon tracking the liquid on the surface and through the soil, assessing the impact of the incident on the environment and creating a remedial response.

Since many hazardous liquids are volatile to some degree, concern must exist for the movement of hazardous vapours through soil from the spill or discharge zone. Very little quantitative information has been published about the problem, although reports of volatile contaminants have been reported at some sites. Consequently, work was undertaken to develop a theoretical model to provide a means of exploring the nature of hazardous vapour movement in soil.

The model is based on the Darcy and constitutive equations for intergranular porous media flow. The equations have been solved analytically for simple site situations and numerically with both finite difference and finite element methods for more complex spill and site geometries. Accommodation has been made for realistic venting of the soil surface, variability in soil composition and moisture content, multiple source configurations such as "pancakes" on the zone of saturation and flexibility in the type of liquid under study.

The search for field or experimental data to calibrate and verify the model has not been successful. However, the model has been used to study vapour movement under many possible spill situations through simulation. The impact on vapour transport in soil of liquid type, liquid source configuration, soil condition and ground surface configuration has been studied and reported upon.

POSSIBLE EFFECTS ON GROUNDWATER QUALITY OF THE USE OF LIQUID INDUSTRIAL WASTES FOR DUST CONTROL ON ONTARIO ROADS

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Key words: Groundwater, Liquid Industrial Wastes, Dust Control, Road Oiling, PCB.

ABSTRACT

This study involved a review of the literature and other information concerning dust control practices in Ontario, with a view to evaluating the potential environmental consequences of those practices. Major sources and distributors of dust suppressants were identified and trends in the use of the various materials were indicated. Presently, there are no reported instances of groundwater contamination as a result of dust control practices, though two cases of surface water contamination by PCBs have been attributed to the use of waste oil. An evaluation of the potential for groundwater contamination is presently limited by a lack of detailed chemical data for most of the suppressants used. It is clear, however, that waste oil has the greatest potential for contamination, while salt brine, in some instances, could lead to local contamination of groundwater by inorganic constituents. Though there is no indication that dust control represents a serious threat to groundwater quality, in order to further resolve the questions, site specific investigations would be required.

CODISPOSAL OF INDUSTRIAL AND MUNICIPAL WASTES

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Key words: Industrial Wastes, Municipal Wastes, Waste Disposal, Landfill, Codisposal.

ABSTRACT

The use of municipal landfill sites for disposal of certain industrial wastes is very attractive because of the availability of disposal sites and relatively low disposal costs. The absorption of heavy metals from electroplating sludges by municipal refuse would appear to support the use of codisposal practice. However, the effects of the combination of industrial and municipal wastes on a long-term basis are not well established.

This project was undertaken to investigate the factors affecting the stability of industrial wastes in a simulated municipal landfill environment. Moderately large leach columns under both environmental and controlled conditions have been set up. A discussion will be given of the short-term laboratory leach test results and the long-term leach column experiments.

EFFECTS OF INCREASING AMOUNTS OF NON-POLAR ORGANIC LIQUIDS IN DOMESTIC WASTE LEACHATE ON THE HYDRAULIC CONDUCTIVITY OF CLAY LINERS IN SOUTHERN ONTARIO

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Key words: Non-polar Organics, Organics, Domestic Waste, Leachate, Hydraulic Conductivity, Clay Liners.

ABSTRACT

The hydraulic conductivity, k, of Sarnia soils, mixed with pure liquids varies from 5×10^{-9} to 1×10^{-4} cm/s as the dielectric constant varies form 80 to 2. Permeation of liquids of low dielectric constant (benzene, cyclohexane, xylene) through compacted, water-wet samples ($k \approx 10^{-8}$ cm/s at $e = 1.0$) showed no changes in k, the hydrophobic liquids displacing only 10% of the pore water from microchannels in the clays. Sequential permeation, first by alcohol ($\mathcal{E} = 30$) followed by a non-polar aromatic yields 10-fold, then 1000-fold, increases in k. The alcohol apparently acts as a mutually soluble association liquid enabling the aromatics to contract the clay double layers.

Current testing of Southern Ontario clays with domestic waste leachates shows little effect on k despite significant retardation and fixation of potassium. Sterilization and bacterial culturing requirements will be discussed.

Results from preliminary testing of clays using domestic waste leachate spiked with known amounts of simple aromatics, with and without alcohol as an association liquid, will be presented, in a first attempt to define threshold concentrations required to initiate detrimental increases in the hydraulic conductivity of clay barriers.

GEOMECHANICAL INVESTIGATION OF NEAR-SURFACE FRACTURES IN CLAY TILLS

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Key words: Clay Till, Nanticoke, Southern Ontario, Waste Disposal, Disposal Sites, Leachate, Near-surface Fractures, Contaminant Migration.

ABSTRACT

The purpose of this investigation is to characterize the nature and variability of near-surface fractures in clay tills of Southern Ontario. To accomplish this, four research sites have been chosen to provide a regional as well as geomorphological variation to the clay soils. These sites are located in the following: Haldimand clay plain at Nanticoke, Essex clay plain near Essex, Lambton clay plain near Sarnia and Port Stanley till near London.

The field work component of this research involves digging trenches with a backhoe down to depths of 13 feet to permit fracture mapping and block sampling, as well as auger drilling and Shelby tube sampling down to a maximum depth of 50 feet. The sampling tubes used have an inside diameter of 4.5 inches.

The laboratory component of this research involves various strength and deformability tests using a triaxial cell and mineralogical analysis using x-ray diffraction. The triaxial tests will determine shear strengths and stress-strain relationships of the clays in triaxial compression and extension. A hydraulic fracturing method will also help determine the tensile strength of the fractured clays in the triaxial cell.

Comparing fracture orientation data, mineralogical analysis results and geotechnical properties of the clay soils, a good indication of the regional variability and behaviour of near-surface fractures in Southern Ontario clays shall be provided.

The results of this investigation will be directly applicable in assessing the suitability of siting waste disposal facilities in surface clay deposits. The behaviour of near-surface fractures during construction and their possible role in future contaminant migration from waste impoundments shall be better understood.

WASTE MANAGEMENT PLANNING FOR THE PHARMACEUTICAL INDUSTRY

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Key words: Waste Management, Pharmaceutical Waste, Waste Disposal.

ABSTRACT

Information obtained on the subject study will be thoroughly reviewed. A questionnaire will be prepared and sent to all pharmaceutical manufacturers in Ontario.

The questionnaire will be based on the types of drugs produced, processes used, chemical or raw materials used, solid and liquid waste produced. There will be questions on the type of wastes (for classification purposes), quantities produced and present methods of disposal (e.g. treatment facility, handlers, disposal companies). There will also be questions concerning the hazardous nature of wastes, chemical analysis, inventory labelling, storage, etc.

Once the questionnaires are mailed, personal interviews will be arranged with the companies who do not respond within a definite time, to obtain first-hand information (and perhaps to explain the questionnaire if not properly understood, its purpose, etc.).

During 1984-85, the main thrust will be to obtain maximum information through interviews and the questionnaire, to establish a data base, inventory requirements and approaches, and also to document regulatory policies and requirements pertaining to the industry.

REFUSE PYROLYSIS EMISSIONS TESTING

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Key words: Refuse, Municipal Solid Waste, Pyrolysis, Emission Rate, Incineration, Hazardous Contaminants, Hazard Assessment.

ABSTRACT

EFW Systems Incorporated has built and is currently evaluating the performance of a 1 tonne/h municipal solid waste (MSW) pyrolysis unit. The feed to the unit consists essentially of shredded MSW combustibles. Low energy gas product will be combusted and used both to sustain pyrolysis and to produce about 350 Kw of electricity.

The Ministry of Energy requested the Ontario Research Foundation to evaluate the performance of the pyrolysis unit, primarily by determining the composition of the gaseous product and by determinig the emission rates of contaminants in the product. Contaminants included in the evaluation were:

- particulate matter
- acid gases
- gases
- dioxins and furans
- PCBs, chlorobenzenes and chlorophenols
- polycyclic aromatic hydrocarbons
- trace metals

The purpose in measuring these emission rates was to identify any potential environmental hazards associated with generation and use of the pyrolyser gases. This included confirming the emission rates of the above contaminants with current environmental standards and developing contaminant emission factors.

APPROACHES TO MINIMIZING SOLVENT EFFECTS IN MUTAGENICITY ASSAYS

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Key words: Mutagenicity, Organic Solvent, Analytical Methods.

ABSTRACT

Testing of potentially hazardous chemicals usually requires that they be dissolved in a suitable solvent prior to administration. In many cases the chemicals are hydrophobic, necessitating the use of organic solvents. Unfortunately, in recent years it has become clear that many organic solvents interfere with or modify the response of an assay. Such solvent effects may include high solvent toxicity, the introduction of solvent derived mutagens or alteration of an assay response to known mutagens. In each case, the data obtained are equivocal and of questionable utility. Even the use of such popular solvents as DMSO has proven unsatisfactory in some assay systems.

Minimising solvent effects is emerging as a major problem in mutagenicity testing. Our approach to the problem has involved testing a variety of natural and artificial oils as potential solvents. Natural plant oils, e.g. corn, olive and sunflower, have low toxicity and suitable solubility characteristics; however, we have found that there remain problems with their use. These problems derive from the aging of such oils and their variable composition, in particular the variable amounts of minor constituents such as tocopherols which have been shown to interfere with the expression of mutagenicity in several assay systems. The use of pharmaceutical grades of plant oils does not eliminate the problems since pharmaceutical standards allow the inclusion of modest and variable amounts of the troublesome ingredients. Clearly, if natural oils are to be used internationally, more restrictive standards for their composition and use will be required. An alternative approach is the use of synthetic oils which include none of the presumed deleterious ingredients. In this case, the solvent composition can be adjusted to provide the best compromise between different chemical and physical characteristics. For example, the degree of saturation of triglyceride substituted fatty acids affects the viscosity, solvent capability and susceptibility to oxidation of triglycerides. We will demonstrate the use of such solvents in a widely used *in vivo* assay system.

LEACHING STUDIES OF PCDD AND PCDF FROM MUNICIPAL INCINERATOR FLYASH

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Key words: Leachate, Dioxins, Furans, Flyash, Water Quality, Municipal Incinerators, Analysis.

ABSTRACT

This study concerns the possibility of polychlorodibenzo-p-dioxins (PCDD) and polychlorodibenzofurans (PCDF) entering the environment through the leaching of municipal incinerator flyash into water. The study also takes into account the effect of the pH of water on the extent of leaching.

Several methods for simulating the actual conditions by which flyash comes into contact with water were investigated. A Soxhlet extraction of flyash with water was finally chosen for this leaching study because of its simulation of the circulation of water in nature and because of its high extraction efficiency. Following the extraction, a simple benzene-water partitioning step was used to transfer the organic compounds in the water extracts into organic solvent for a subsequent GC and GC/MS analysis. Good recovery of PCDD at the 2 ppt level was obtained using benzene partitioning.

The analytical results for water extracts at pH levels of 4, 7, and 10 show clearly that PCDD and PCDF enter water through leaching. These compounds were found in water at the 1 to 400 ppt level. Because of these low concentration levels, the reproducibility and accuracy of quantitative results were poor.

The study was extended to identification of other organic compounds that were also leached from the flyash into the water extracts. Identification of these organic compounds was accomplished using the techniques of GC/FID, GC/EIMS, GC/PICIMS and GC/NICIMS. These compounds were present at higher concentrations than the PCDD and PCDF and many were chlorinated and toxic. At pH 4, a total of 71 compounds were found; at pH 7, 64 were found, and at pH 10, 56.

DEVELOPMENT AND VALIDATION OF PROTOCOLS FOR SAMPLING SURFACE AND GROUNDWATERS FOR ORGANIC CONTAMINANTS

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Key words: Water Quality, Groundwater, Volatile Organics, Water Sampling.

ABSTRACT

In the first phase of this research, present methods of sampling waters, especially groundwaters, for subsequent analysis of volatile organic contaminants were evaluated. The major sources of bias included well flushing procedures, sorption onto sampling equipment and volatilization due to exposure of samples to the atmosphere during sampling.

Following a review of the literature, a series of laboratory experiments were conducted which evaluated the bias and variability of results when groundwaters are sampled by various techniques. The performance of a suction lift system (peristaltic pump) and a gas-drive system (triple-tube sampler) were evaluated. Both systems introduced some negative bias (0.8 to 21.6%) but little variability with standard deviation of less than 10% of the mean. Surprisingly, the suction lift system induced less volatile-loss than the positive-pressure gas-drive system.

It is concluded that monitoring programs should be as standardized as possible. Requirements for well flushing, in particular, may be difficult to establish a priori. For volatile organics, the major source of bias appears to be volatilization loss and so a sampling system which eliminates this loss will be investigated in phase two of this research.

LABORATORY STUDY OF TILE DRAIN EFFICIENCIES FOR LEACHATE COLLECTION

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Key words: Tile Drainage, Leachate, Leachate Collection, Hydraulic Characteristics.

ABSTRACT

A physical 2-dimensional model using a homogeneous and isotropic sand medium, with water as the fluid, was tested to determine the effectiveness of tile drain systems in capturing groundwater recharge from infiltrated precipitation. For a landfill, this recharge is leachate. Experiments were conducted for configurations with varying hydraulic gradients, position of the tile within the flow field, thickness of the flow field, tile spacing and recharge rate. All experiments were for the steady state condition.

Original gradients were established by varying both the recharge rate at the upper surface and the hydraulic head in a permeable "aquifer" that formed the lower boundary of the model.

The ratio of flow that bypassed the tile drain(s) to the total recharge (input) to the system (Q_A/Q_R) is a measure of the efficiency of the tile system for leachate collection.

Graphs of Q_A/Q_R vs R/K_s (recharge/saturated hydraulic conductivity) for different positions of the tile drain(s) and spacing of tile drain(s) (H_D/L), show that unless the tile is placed at an elevation below the hydraulic head in the aquifer, some water (leachate) will bypass the collection system.

In our model studies, the water table is a consequence of the parameters of the medium and the experimental conditions but the position of the water table is not a factor in evaluating the performance of the tile drain(s).

DEVELOPMENT OF DESIGN CRITERIA FOR OPTIMAL RECOVERY OF LEACHATE UNDER SANITARY LANDFILLS

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Key words: Leachate, Leachate Recovery, Sanitary Landfills, Landfill Design.

ABSTRACT

This study proposes a numerical approach to evaluate the efficiency of leachate collection systems under landfills. It applies a finite element model to a 2-D steady-state flow system of variable hydraulic parameters and spatial dimensions.

Results for homogeneous, isotropic media show that most leachate can be collected if an upward gradient exists between the drain level and the bottom of the system. If the gradient is downward, the drains have to be closely spaced in order to collect the leachate. Drain performance depends also on the rate of recharge to the system which controls, in part, the height of the groundwater mound between tiles. Optimum recovery is attained when all leachate is collected with minimum infiltration from regional aquifer water. Further results show that natural and artificial anisotropy or layering in the porous medium can increase significantly the performance of a given design. Consequently, the presence of such characteristics can be a determining factor in the creation of efficient leachate recovery systems.

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